IN SITU HR-EBSD DURING MICRO-MECHANICAL TESTING FOR MICROSTRUCTURE, STRESS AND PLASTIC DEFORMATION CHARACTERIZATIONS IN MATERIAL

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The constant progress in miniaturization of micro-mechanical parts brings the necessity to assess and understand the deformation mechanisms of materials at small scale. SEM in situ nanoindentation has emerged as the technique of choice since it allows routine testing of small volumes of materials in a highly controlled fashion and with high data resolution. We recently developed the capability to conduct electron backscatter diffraction (EBSD) during micro-mechanical testing. Combined with the cross-correlation technique (HR-EBSD), the strain/stress field and the GNDs distribution can be mapped at several steps during progressive deformation [1-2]. This data can provide new insights in order to understand deformation mechanisms in materials. A review of the technique will be presented in different context and for different materials.

The first example will be given for micropillar compression in titanium in order to understand how the local stress field and dislocation distribution influence twin formation and evolution. The local shear stress on the active twin variant has been determined and compared to the global shear stress determined by pillar compression. Results show that the active twin variant that forms during compression does not have the highest global shear stress but a higher local shear compared with other twin variants. The experiments show that elongation of the active twin involves a competition between local shear stress and dislocation density in front of the twin tip, which leads to a discontinuous elongation process. The second example is the investigation of martensite growth in shape memory FeMnSi-based alloys using micropillar compression. Similar to twins, the results show that the activation of a stress-induced martensitic hcp variant is not necessarily predicted by the global Schmid factor but can be explained with local stress field and dislocation emission analysis. Several examples at the vicinity of grain boundaries will be shown. The third example is the use of in situ EBSD during notched and un-notched microcantilever bending of single crystal tungsten in order to understand scale effects on fracture toughness and bending stress, respectively. The stress and GND distributions are mapped at successive deformation steps and compared to beam bending theory and finite element calculations.

[1] Guo, Y., Schwiedrzik, J., Michler, J., Maeder, X., Acta Materialia 120, 292-301, (2016).
[2] Ast, J., Mohanty, G., Guo, Y., Michler, J., Maeder, X., Materials & Design 117, 265-266, (2017).